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METEOROLOGICAL RESEARCH COMMITTEE

Note on the structure of the high altitude strong wind belt in the Middle East in winter

by

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Summary

From an analysis of the upper air observations at Habbaniya and Bahrein for January 1951 a meridional cross-section is constructed showing the mean structure for that month of the strong wind belt in the upper troposphere over Iraq. The analysis is subjective and liable to errors, but the self-consistency of the results indicates some reliability.

1. Introduction

The strong winds which blow in the upper troposphere over the Middle East in winter and spring are well known. Frost(1) and Gilchrist(2) have shown meridional cross-sections of the mean flow of the air over Iraq in January and April. This strong wind belt can certainly be associated with the polar front. It is also probably in part a continuation of a strong flow which is found in the upper troposphere in many longitudes between Lats. 25 and 40°N (2 and 3). The structure of this strong wind belt, whether it resembles a jet-stream of more temperate latitudes or is less sharply defined, is in some doubt.

The following note describes an attempt to discover the structure of this stream from a study of the observations at Habbaniya (33°22'N 43°34'E) and Bahrein (26°14'N 50°25'E) twice daily in January 1951.

2. Method of analysis

Temperature and wind data for Habbaniya and Bahrein for the levels 400 mb. and upwards were plotted for each hour of observation in January 1951 as shown in the examples in Fig. 1 which give data for 12 - 14th January. Mean wind direction between 300 and 100 mb. is given below each mean plot; variation about this mean was usually less than 15 to 20° - wind direction seldom changes much with height at those levels in the Middle East. Tropopause levels were determined using the experimental definitions given in reference (4).

From the observations plotted as in Fig. 1 an estimate was made of the plan position of the axis of strongest winds relative to the two observing stations. Fig. 2 shows the method of classifying the position of the axis. The positions are recorded on Fig. 1 for the relevant observations. In doing this, consideration was given to continuity and to the rise or fall of

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temperature in the middle troposphere as indicating northward or southward motion respectively. The estimates are, therefore, subjective and must be liable to considerable error on occasions. It should be mentioned that the analyst may well have been influenced by a knowledge of the typical variations in jet-streams of temperate latitudes, but since some of the results of the analysis are dissimilar to those for a jet-stream this source of error may not be serious.

From each pair of observations an estimate was made of the minimum width of that part of the stream with a speed of 100 kt. or more. For example (see Fig. 1) the minimum width of the strong winds at 14 G.M.T. 14th was estimated as 400 mi., allowing for wind direction and the fact that the wind was appreciably greater than 100 kt. at both Bahrein and Habbaniya. Such estimates were largest when the axis of the stream was north of Habbaniya (zone (VI)), the wind then often exceeding 100 kt. at both stations. This result is to be expected if the axis of the strong winds is nearer the polar edge of the stream. The mean value of such minimum widths was 520 mi. for the 21 cases in zone (VI).

Next, the observations at the two stations were collected together according to the position of the axis and means were formed of the parameters plotted in Fig. 1. In the first instance this was done for wind observations only, but, as the results appeared encouraging, temperatures and tropopause levels were also averaged. On many occasions a level of maximum wind was not observed as wind was still increasing with height when observations ceased as the radar target passed out of range. To take some account of these, a minimum mean height and speed of the maximum wind was computed for each zone by taking the last wind observation as the maximum wind when wind was still increasing with height.

All these mean values were then plotted as shown in Fig. 3. If we assume that northward or southward fluctuations of the position of the stream do not affect its mean characteristics, (an assumption which is probably not fully justified; see below) then we may consider the mean values plotted in Fig. 3 as referring to stations at fixed intervals across a mean stream. Habbaniya is approximately 400 mi. north of Bahrein and the mean wind in the upper troposphere over Iraq was approximately westerly in January 1951, so that the interval between the plots may be taken as about 100 mi.

Isopleths of mean wind speed have been drawn on Fig. 3. Loss of observations at the higher levels makes some of the plotted mean values at 200 mb. and above unrepresentative and some allowance has been made for this in drawing the isokinetics. The minimum heights and speeds of the mean maximum wind computed as described above were also used in assessing the position of the central isopleths.

Isopleths of potential temperature were also drawn on Fig. 3 from the mean temperatures plotted. Like the isokinetics they appear to follow a pattern and the slopes of these lines were used to reassess levels of maximum wind assuming the geostrophic relation and hence to make minor corrections to the isopleths of mean wind.

3. Discussion

It is perhaps surprising that the subjective analysis described in Section 2 should produce such a self-consistent picture as Fig. 3. This consistency probably indicates that on the average the assessments of position of the axis of the stream were not far out and that the assumptions made in the analysis were mainly valid. It will be noted, however, that there is only limited agreement between the observations at Habbaniya in zones (V) and (VI) and Bahrein in zones (I) and (II) where the two sets should overlap in Fig. 3. This is some indication that the stream differs

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in detail (temperatures, tropopause levels, etc.) according as it is north or south of its mean position, though it does not necessarily show that the structure of the stream varies with position.

Another discrepancy in the analysis is that though each pair of observations was classed as in Fig. 2 the axis of the stream in Fig. 3 appears not at Habbaniya (V) but nearer Habbaniya (VI) and Bahrein (II). This fault is not considered serious, in view of the roughness of the classification.

Points of interest are

(i) The stream appears to be wide and without the strong horizontal gradients of wind speed which are found in typical jet-streams of higher latitudes. The 100 kt. isokinetic is seen to be about 700 mi. wide, i.e. the mean width of the strong stream (100 kt. or more) is almost 10° of latitude. That this estimate is not greatly in excess of the true value is shown by the mean lower bound of 520 mi. for occasions in zone (VI) (see Section 2). There remains the doubt, however, whether this method of analysis is adequate to show up a really strong horizontal shear occurring on the polar side of the stream.

(ii) The level of maximum wind falls southwards through the strong wind belt. This is the reverse of what is found in the typical frontal jet-stream of middle latitudes. It may be argued that this result may be incorrect, because more ascents failed to reach the level of maximum wind in the stronger winds on the right-hand side of Fig. 3. This effect must certainly be present, but some allowance has been made for this in drawing the isopleths and the weight of the evidence is for the result as stated. For example, there is little doubt that the level of maximum wind is above 200 mb. at the centre of the stream and below 200 mb. at the point Bahrein (IV). This sloping downwards to the south of the level of maximum wind may be detected on the mean meridional section for January 1951.(2)

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(iii) The upper tropopause does not appear to vary greatly; it is consistently higher at Bahrein than at Habbaniya.

(iv) The lower tropopause appears to slope upwards towards the axis of strong winds but the evidence for this on the south side of the axis is slender.

4. Conclusions

Many criticisms may be made of the above rough analysis. If the results in Fig. 3 are accepted because of their self-consistency, it appears that in January 1951 the strong wind belt over Iraq and the Persian Gulf was in the mean a broad stream without strong horizontal gradients; its axis was about 190 mb. and the breadth of the highest speeds (100 kt. or more) was about 700 miles.

References

(1) Frost, R. — The upper air circulation in low latitudes and its relation to certain climatological discontinuities. Met. Res. Pap. 706, 1952.

(2) Gilchrist, A. — Upper winds in the Tropics and Sub-Tropics. Met. Res. Pap. 795, 1953.

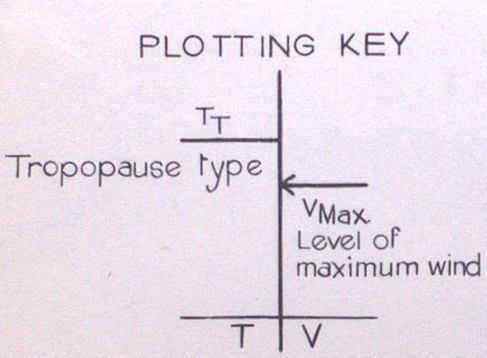
(3) Namias, J. and Clapp, P.F. — Confluence theory of high tropospheric jet-stream. J. of Met., 6, 1949, p. 330.

(4) - — Upper air data, 1946-50, Habbaniya. M.O. 555, Part 3, 1953.

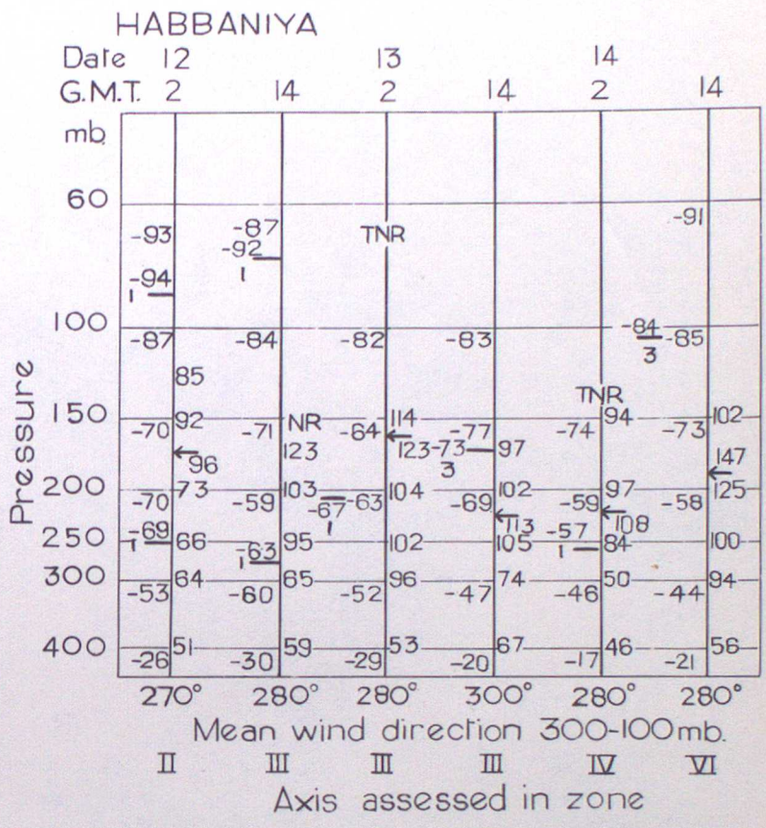
M.R.P. 821

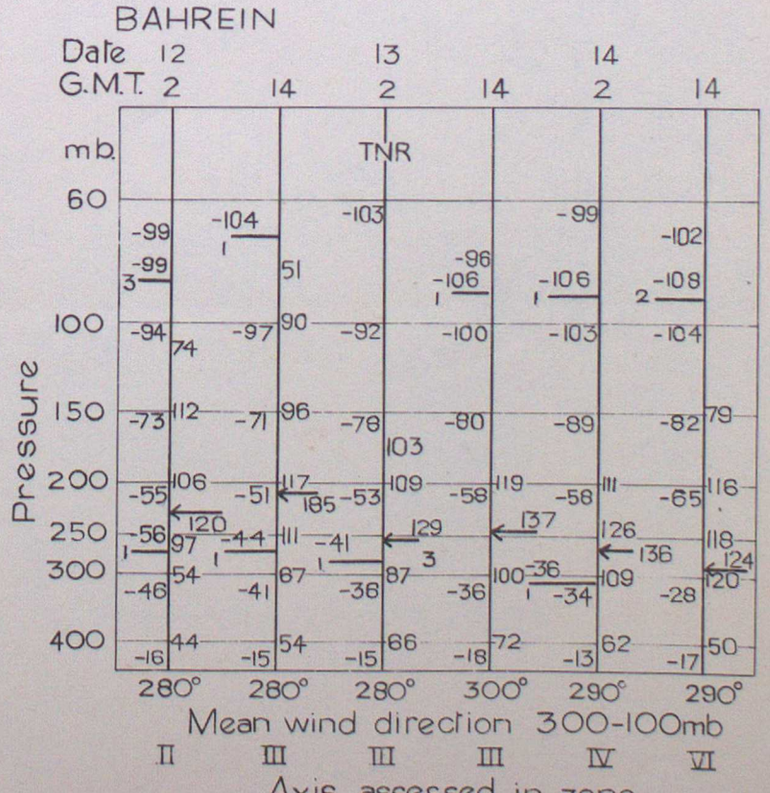
Fig. 1

Upper winds and temperature at Habbaniya and Bahrein 12-14th January, 1951



T = Temperature °F.
T_T = Temperature at the tropopause
V = wind speed (kt.)
$V_{Max.}$ = Maximum wind speed
TNR = Upper tropopause not reached
NR = Level of maximum wind not observed





M.R.P 821

Fig. 2

Position of zones relative to Bahrein and Habbaniya

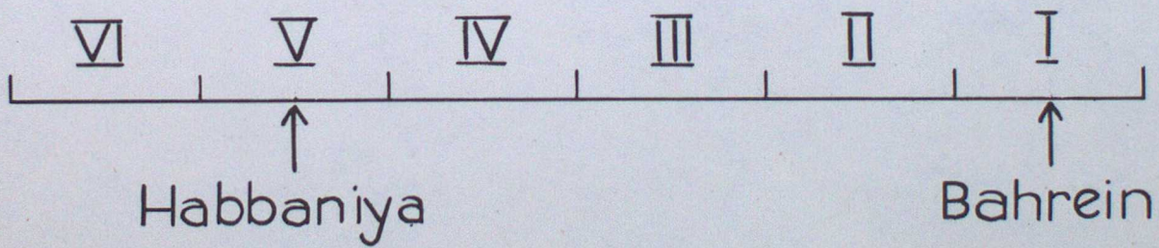
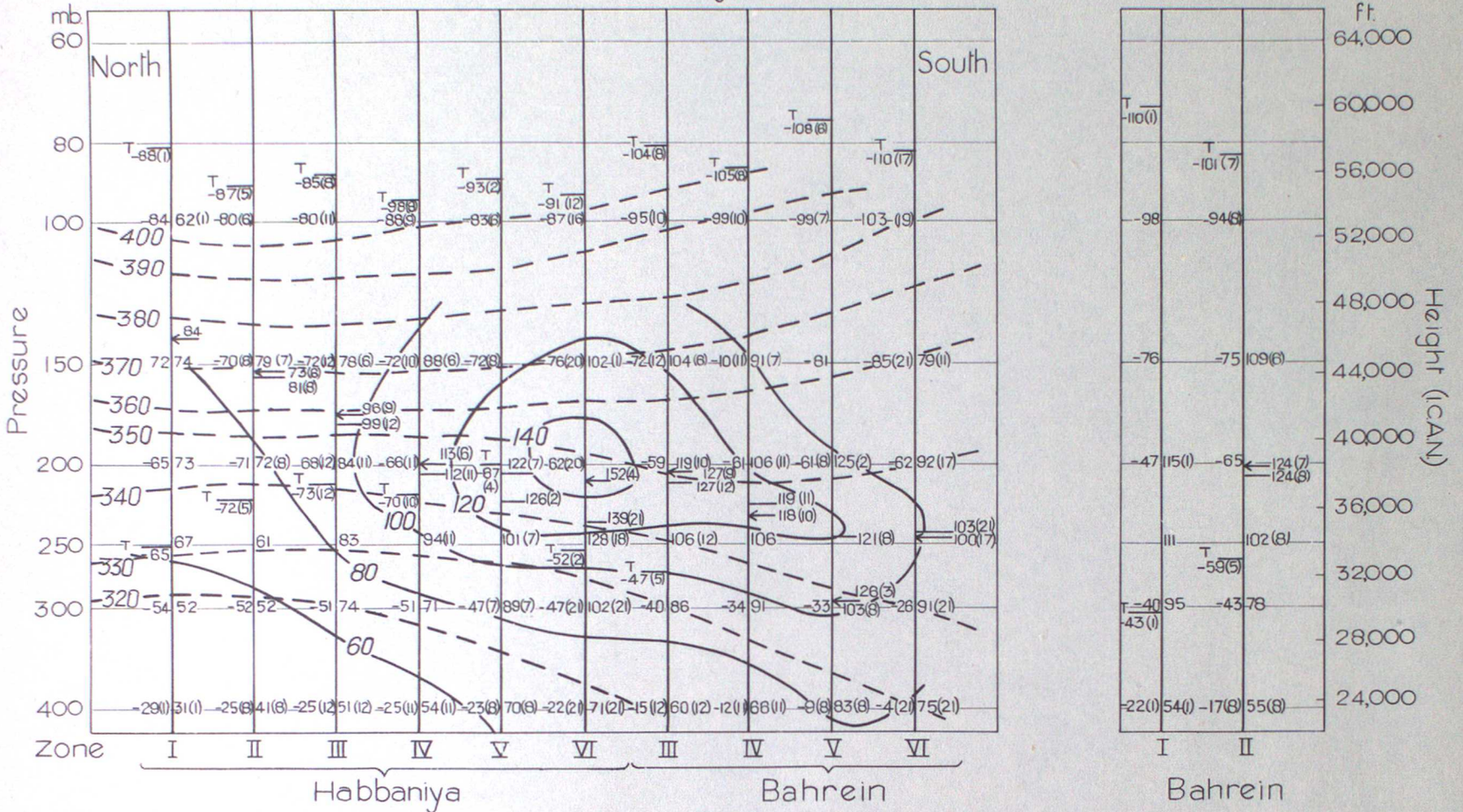


Fig. 3
Constructed mean cross-section for 45°E
January, 1951



Model

T
ff(n)
Vmax (n)
Vmm (n)
ff(n) V(n)

T = Tropopause
ff = Temperature (°F)
n = Number of observations
V = Mean wind speed
Vmax = Mean maximum wind speed from available observations
← = Mean level of maximum wind speed (observed)

Vmm = A lower limit to true mean maximum wind speed
⊢ A lower limit to the true mean level of the maximum wind
—— Isokinetics (kt)
– – – Isopleths of potential temperature (°F)